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SYMPOSIUM OF SCIENTIFIC SATELLITE PROJECTS

Special Committee on Space Study
of the
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SYMPOSIUM OF SCIENTIFIC SATELLITE PROJECTS

ABSTRACT

Opening Address

Kankuro Kaneshige

(Chairman of the Special Committee for Space Study of
the National Science Conference of Japan)

A study of space science using rockets has been conducted for several years, and observations on more than ten phenomena have been performed every year. Based on these results, a project for launching scientific satellites for the purpose of scientific observations has been discussed within this committee, as well as among specialists.

It is our purpose to report on this process to the outside, and to listen to the opinions of the people concerned which will be helpful to the project sponsored by this committee.

Thus, the following speeches have been prepared for the purpose of reporting on the results of scientific observations via rockets, and of introducing the intermediate plan of the scientific satellite project of Japan.

Current Status of Rocket Technology

Akio Tamaki

(Space and Aeronautics Laboratory of the University of Tokyo)

A report is made on the development of rocket technology during the past decade. A rocket project for scientific observations of the University of Tokyo was started in 1955. The K-6 (Kappa-6) rocket was launched in 1958 to an altitude of 60 km to measure the temperature and wind direction.

In 1959 K-8 was planned to follow K-6. The first-stage rocket of K-8 had a diameter of 420 mm. The two-stage rocket K-8 was completed in 1960, and reached an altitude of 200 km.

After the completion of K-8, the following three projects were carried out in parallel.

- 1) Development of the three-stage rocket K-9L;
- 2) Improvement of K-6 and K-8;
- 3) Development of Lamda rocket.

The K-9L made the first successful flight in April, 1961, reaching an altitude of 350 km.

For the future development of the four-stage rocket, Mu, the following steps are to be followed:

- 1) Attitude control engine.

The engine will use the vapor produced by hydrogen peroxide.

- 2) Spherical rocket.

This will be tested in space by K-420

- 3) The launching tests of K-10 and K-10S are planned in the near future.

- 4) The attitude detection will be tested by K-10.

5) The first-stage M-10 engine of the four-stage rocket M-4S was successfully tested on the ground in May of this year. The ground test of the second-stage, whose length is about 1/3 of the first stage, was completed in March of last year.

- 6) The two-stage rockets of uniform diameter will be tested with respect to their stability during a flight by K-10.

- 7) Auxiliary boosters will be developed in parallel.

Status of Space Electronics

Shigebumi Saito

(Institute of Industrial Science)

1. Introduction

The equipment which is used for space electronics and for the ground station launching will be explained. Also the future plans in this line for the Mu rocket will be illustrated.

2. Space Electronics

As for the space electronics, telemetry, radar, and command, are of major importance.

The telemetry adopts the frequency modulation method and the time-division multiple method. The frequencies are 225 Mc ~ 298 Mc. There are three recorders having 15 channels, respectively, at the ground station.

There are two antennae for space communication. One is 30 m in diameter located at Kashima, owned by the Wave Propagation Laboratory, the other is at Juoji owned by the International Telephone and Telegram Company of Japan, and is 20 m in diameter.

The one having a diameter of 18 m is used for receiving telemetry signals from the rocket. Also a helical antenna is used for receiving polarized waves.

Radars are equipped so as to determine the location of rockets during flight. The signals from the ground station which are

pulse-modulated at the rate of 250/sec \sim 833/sec are received by the transponder carried by the rocket, and they are transmitted back to the ground. The distance to the rocket can be measured by the round-trip time of the signals. Its location can be determined by detecting the azimuth and elevation angles of the antenna. There are two radars. One is an antenna having a diameter of 2 m, another is a parabolic radar which is 4 m in diameter.

Parametric amplifiers with extremely low noise temperature are used for the receiver to detect very weak signals.

Commands which will be sent to stop the ignition of the second and third stage ignitors for emergency are carried by the 410 Mc wave. This carrier is modulated by two audio tones.

The television which will be carried by the rocket has been developed during these two years, and is waiting for the rocket to carry it.

As a future plan, a controlling radar is required to take data of the artificial satellite in real time. The accuracy of the conventional radar was about 100 m in distance and $0.1^\circ 6'$ in angle. However, one having an accuracy of less than 10 m in distance, and $30''$ in angle, is now on the planning boards. A real-time computer will be installed for processing data in real time and for filtering data so as to indicate their estimated value, and for tracking the rocket so as to predict its future trajectory.

For telemetry of the scientific satellite, the FMFM scheme will be adopted. Besides a digital scheme, the so-called PCM scheme will

be introduced, taking advantage of the digital computer.

As for the command signal to the satellite, a special command system of approximately 15 items, which is very resistant to noise, is being developed.

A light communication using gas laser for commanding is also under investigation.

3. Ground Equipment for Launching Rockets

Electronic equipment for launching rockets belonging to the existing ground system at the Kagoshima station are illustrated in detail.

Achievements by Rocket Observations

Kenichi Mayeda

(Engineering Department, University of Kyoto)

1. Observational Objectives

- a) Atmospheric structure;
temperature, direction, and speed of wind.
- b) Ionosphere, space plasma;
density of electrons and ions, energy distribution of thermionic electrons, ionic composition.
- c) Magnetic and electric field;
permanent magnetic field, daily variation of magnetic field, magnetic pulsation, local magnetic field, electric field.
- d) Wave propagation phenomena;
wave propagation, electro-magnetic wave noise electron density (doppler method, impedance method), number of impacts (decaying method).

e) Radiation (light);

atmospheric light, solar ultraviolet ray; X-ray, γ -ray.

f) Particle rays;

cosmic rays, pseudo-cosmic rays, light particles, heavy particles.

2. Survey of Observations

a) Atmospheric structure.

The observations of wind and temperature have produced data below 50 ~ 60 km throughout the four seasons. This was useful for studying the so-called prevailing wind.

Observations of wind above 80 km are being conducted under the international cooperative program.

b) Ionosphere, space plasma.

The density distribution between E and F layers was clarified for day- and night time by the measurement of electron density. Electron density and temperature were measured to an altitude of 1000 km by K-9, L-2 and L-3.

c) Electric field, magnetic field.

A slight discontinuity of the magnetic field distribution was observed at an altitude of 105 km by the flux-gate type magnetometer recently.

d) Wave propagation phenomena

The study of wave propagation noise was started long ago. However, no significant results have been obtained, except for data on the lower-frequency band noise.

e) Radiation (light).

The altitude of the atmospheric light during the night time (5557 Å) was determined. The atmospheric light in day time was also observed at the visible range of 2,000 ~ 3,000 Å. These observations are intended to study the phenomena of excitation and resonance of O₂, NO, and O in the day time by solar ultraviolet rays, and to relate them with the ionic density and the electron temperature in the ionosphere.

f) Particle rays.

Experiments using GM counters have been conducted since the early stages, in order to acquire the vertical distribution of cosmic rays up to an altitude of 1,000 km.

Experiments using PHA have been started to clarify the type of, and energy distribution of, particle rays in the range just below the Van Allen belt.

The Scientific Satellite Project
(From the Technical Point of View)

Hideo Itogawa

(Space and Aeronautics Laboratory)

1. Is it necessary to develop a rocket system for launching scientific satellites in Japan?

Those countries such as England, Canada, Italy and France have already asked NASA of U.S.A. to launch their satellites. The advantages of asking NASA to launch satellites lie, in the first place, in the fact that it can save expense for research and development, especially the expense related to the research and development of rockets. In

the second place, the expenses for tracking stations can be dispensed with. However, the disadvantage of asking NASA is that it takes at least three years for such procedures as presenting the project of Japan to NASA, establishing a liaison committee, and testing the satellite equipment by NASA. Therefore it will be delayed for 1 - 2 years over the M4S project undertaken by Japan herself.

The advantages of launching rockets by Japan herself are: (1) it will be achieved earlier than asking NASA to do so; (2) her own project can be planned; (3) it can dispense with the loss caused by the long residence of scientists and engineers outside the country; (4) technical output of research and development will contribute to the industry.

Thus, the conclusion of the speaker is that launching by our own hands using M4 will be more advantageous than requesting NASA to do so, although he does not exclude the possibility of the latter.

2. Conditions to be considered for launching rockets.

- a) Economy;
- b) Safety;
- c) Taking advantage of the technique which has already been developed.

Although the Kappa and Lamda series are hopeless as orbiting satellites, the Mu rocket may be used for that purpose.

- d) Control.

A new guidance control method is proposed which is to release the satellite at the instant when the rocket reaches its highest

point.

e) Level of the industry.

Sufficient technology has been developed to produce a rocket having a diameter of 2 m, so that the production of Mu rockets (1.4 m) is no problem. The detectors to be used for the attitude control have been developed based on these basic devices - namely, gyro, magnetic field sensor, and solar sensor. The engine for the attitude control using hydrogen peroxide has already been designed. The technology of telemetry and radar will be sufficient with the current electronics technology of Japan.

However, the technique for data processing has not been completed yet. The real-time data processing technique must be further developed.

Scientific Satellite Project

Kunio Hirao

(Wave Propagation Laboratory)

1. Instruments

Instruments for measurement of the wave propagation noise, cosmic rays, ions, electron density and temperature will be carried by the first scientific satellite.

A severe restriction on these instruments will be the power limitation. Output signals which are suitable for the PCM telemetry must be developed.

2. Power Source

The first satellite may require about 20 W power which will be supplied by approximately 3,000 solar cell elements. As a secondary battery, which is charged by these solar cells, a Nickel-Cadmium battery will be suitable.

3. Structure

The structure of the satellite must be designed so as to endure severe conditions during the launching phase and to satisfy the objectives of the experiment during the orbiting phase.

4. Telemetry, Program Timer, Tape Recorder, and Command

The PCM telemetry method is adopted for the telemetry of the satellites. It has been decided that one frame consists of 32 words, one word consists of eight bits, and two frames will be used while one frame takes 2 seconds.

5. Antenna System

It is desirable for the antenna that the intensity of receiving signals does not change with the attitude of the space craft. Perhaps the one used for the IMP and UK satellites will be adopted.

6. Mechanical Environment

Various tests must be performed on the space-craft to determine the effect of shock, vibration, and acceleration during the launching phase of rockets. Also the spinning balance of the space-craft is an important problem.

7. Parts and Components

Reliability of more than ten thousand parts and components which

constitute a space-craft becomes a serious problem.

8. Thermo-vacuum Environment

The thermionic balance between the solar radiation and the heat loss of the space-craft during the orbiting phase is to be maintained in such a way that the inner temperature will remain around room temperature. The active control of such a heat balance for a small satellite is very difficult. Passive control may be performed by painting the surface of the space-craft with suitable materials.

9. Radiation, X-rays, Ultraviolet Rays

So-called radiation damage is expected on solar cells and on transistor elements if the satellite orbit passes through the Van Allen belt. Therefore, radiation tests on the components becomes necessary.

10. Data Acquisition and Tracking

The equipment for telemetry and tracking at the ground station are investigated. The method of data reduction is discussed. The orbit determination using the doppler method is studied for tracking.

Closing Speech

Nobom Takagi

Various aspects of the scientific satellites have been discussed in this symposium. It may require at least two years for completion of the multi-stage M rocket. It will be first tested as an observational rocket. The ground systems must be completed by then. Many technical problems must also be solved if a scientific satellite is

launched by the M rocket. Also the development of the satellite itself should be started immediately.